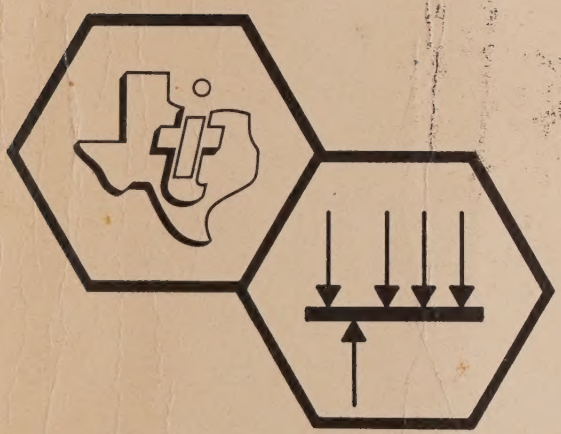
Bill Mitchell
APR.61

OPERATING INSTRUCTIONS MANUAL

CRYSTAL RESISTIVITY METER

MODEL 635

MANUAL NO. 190204

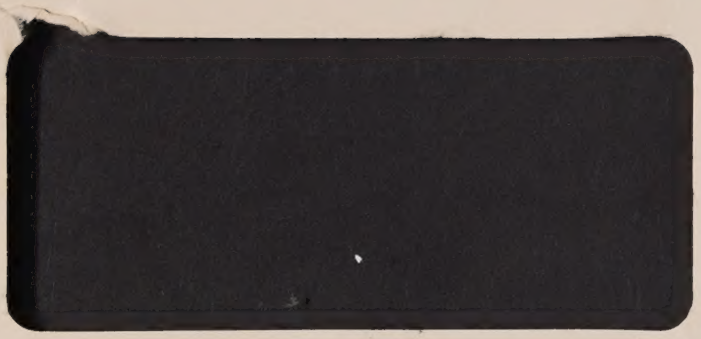


TEST EQUIPMENT

FROM

APPARATUS DIVISION
PLANTS IN HOUSTON
AND DALLAS, TEXAS

TEXAS INSTRUMENTS
INCORPORATED
3609 BUFFALO SPEEDWAY
P. O. BOX 66027 HOUSTON 6, TEXAS



CRYSTAL RESISTIVITY METER

MODEL 635

MANUAL NO. 190204

TEXAS INSTRUMENTS
INCORPORATED
3609 BUFFALO SPEEDWAY • HOUSTON 6, TEXAS • CABLE: TEXINS

COPYRIGHT APRIL 1961

BY

TEXAS INSTRUMENTS INCORPORATED

ALL RIGHTS RESERVED

THE INFORMATION AND DRAWINGS SET FORTH IN THIS DOCUMENT AND ALL RIGHTS IN AND TO INVENTIONS DISCLOSED HEREIN, AND PATENTS WHICH MIGHT BE GRANTED THEREON DISCLOSING OR EMPLOYING THE MATERIALS, METHODS, TECHNIQUES OR APPARATUS DESCRIBED HEREIN ARE THE EXCLUSIVE PROPERTY OF TEXAS INSTRUMENTS INCORPORATED.

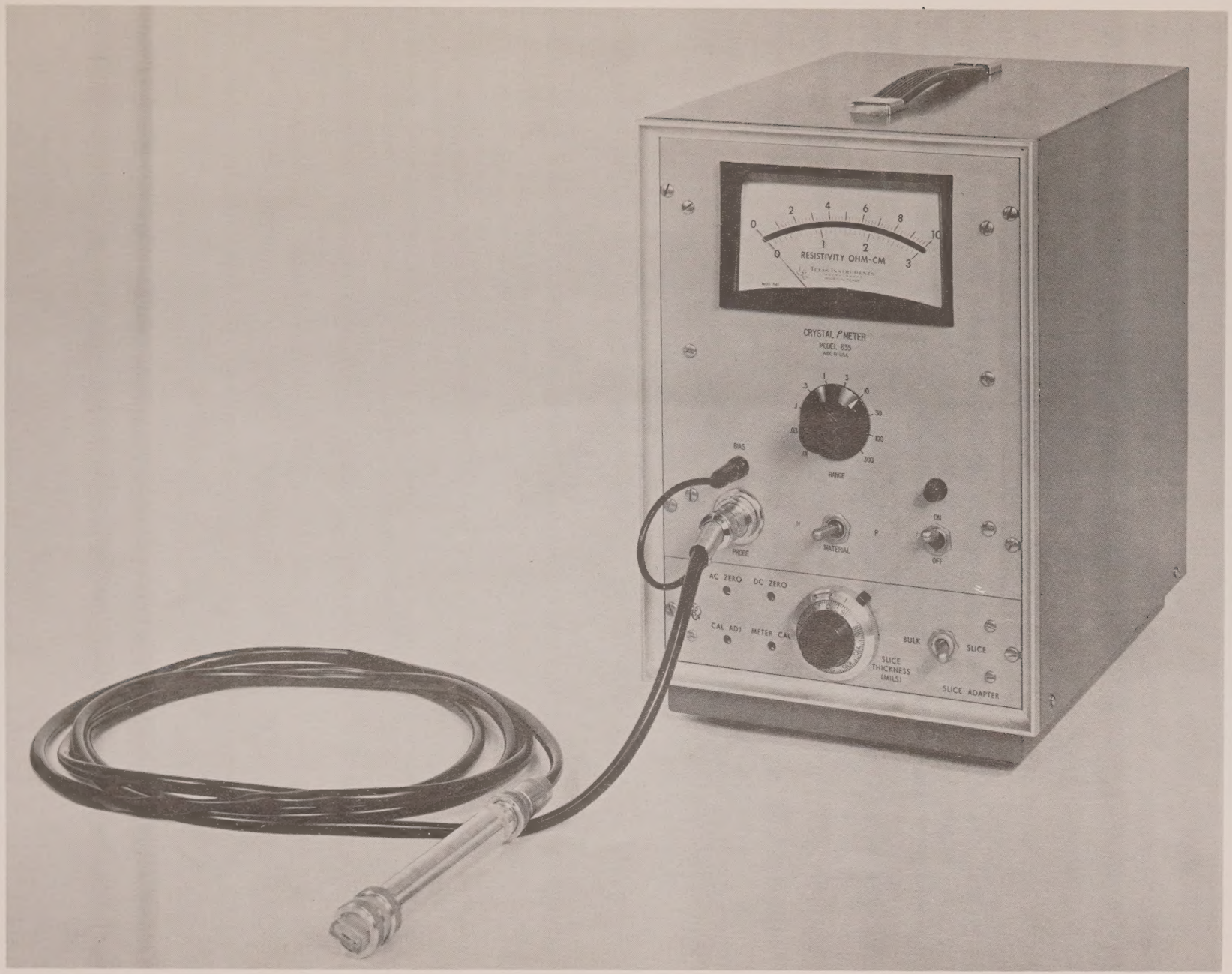
NO DISCLOSURE OF THE INFORMATION OR DRAWINGS SHALL BE MADE TO ANY OTHER PERSON OR ORGANIZATION WITHOUT THE PRIOR CONSENT OF TEXAS INSTRUMENTS INCORPORATED.

TABLE OF CONTENTS

SECTION	TITLE	PAGE
I	GENERAL INFORMATION	
	I-1 INTRODUCTION AND DESCRIPTION	1-1
	I-2 SPECIFICATIONS SUMMARY	
	2.1 MECHANICAL	1-2
	2.2 ELECTRICAL	1-2
II	INSTALLATION	
	II-1 UNPACKING AND HANDLING	2-1
	II-2 CHECKING	2-1
	II-3 OPERATING LOCATION	2-1
	II-4 CALIBRATION	2-1
III	OPERATION	
	III-1 FRONT PANEL CONTROLS	
	1.1 INSTRUMENT PANEL CONTROLS	3-1
	1.2 SLICE ADAPTER PANEL CONTROLS	3-2
	III-2 OPERATIONAL PREPARATION	3-2
	III-3 OPERATING PROCEDURE	3-3
IV	OPERATIONAL THEORY	
	IV-1 GENERAL	4-1

TABLE OF CONTENTS
(Continued)

SECTION	TITLE	PAGE
IV-2	CIRCUIT DESCRIPTION	
	2.1 SQUARE WAVE GENERATOR	4-1
	2.2 CONSTANT CURRENT SUPPLY	4-2
	2.3 DECADE AMPLIFIER	4-2
	2.4 EXTERNAL SLICE CIRCUIT	4-3
	2.5 PHASE-SENSITIVE DETECTOR	4-3
	2.6 POWER SUPPLIES	4-3
	2.7 INPUT SHORTING RELAY	4-4
V	MAINTENANCE	
V-1	ALIGNMENT	5-1
V-2	VOLTAGE MEASUREMENTS	
	2.1 AMPLIFIER VOLTAGE CHART	5-6
	2.2 OSCILLATOR VOLTAGE CHART	5-6
V-3	PROBE POINT REPLACEMENT	5-7
V-4	TROUBLE SHOOTING CHART	5-8
VI	REPLACEABLE PARTS	
VI-1	GENERAL	6-1
VI-2	REPLACEABLE PARTS LIST	6-2
VII	PACKING AND SHIPPING	
VII-1	GENERAL	7-1
VII-2	PACKING INSTRUCTIONS	7-1


RESISTIVITY OHM-CM
CRYSTAL ρ METER
MODEL 635
RANGE
BIAS
PROBE
MATERIAL
N
P
ON
OFF
AC ZERO
DC ZERO
CAL ADJ
METER CAL
SLICE THICKNESS (MILS)
BULK
SLICE
SLICE ADAPTER

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_05448

SECTION 1 - GENERAL INFORMATION

I-1 INTRODUCTION AND DESCRIPTION

The TI transistorized, direct reading Model 635 CRYSTAL RHO METER accurately determines the resistivity of either bulk or slice crystals. Ten resistivity ranges provide increased accuracy.

The unit accepts a four-point resistivity probe and the new Texas Instruments five-point probe. The five point probe features a built-in bias contact to reduce probe impedance.

The points used in the TI probe are Permametal needles made from heat treated high alloy steel. They maintain their sharpness for long periods of production usage. Synthetic ruby guide bearings maintain probe spacing between points at a constant 45 mils. Tension of the replaceable, spring-loaded tips is factory-set for either silicon or germanium.

SECTION 1 - GENERAL INFORMATION

1-2 SPECIFICATIONS SUMMARY

2.1 MECHANICAL

DIMENSIONS	H-12-1/8" W-8-1/2" D-11-7/8"
WEIGHT	Approximately 15 lbs.

2.2 ELECTRICAL

RESISTIVITY RANGE	0.01, 0.03, 0.1, 1.0, 3.0, 10, 30, 100, and 300 ohm-cm full scale.
CONSTANT CURRENT SOURCE	1000 cps, a-c square wave.
RESISTIVITY READOUT	Displayed on a sensitive five-inch meter with 0 to 3 and 0 to 10 mirrored scales.
d-c BIAS	Used to reduce probe contact resistance.
SLICE THICKNESS RANGE	When BULK-SLICE switch is in SLICE position, slice thicknesses from 0.007 to 0.037 inches may be directly dialed on a calibrated three-turn potentiometer.
NOISE REDUCTION	Noise level is greatly reduced by the use of a phase sensitive detector to drive the meter.
POWER REQUIREMENTS	115-120 V, ac, 60 cps, at approx. 15W.

SECTION II - INSTALLATION

II-1 UNPACKING AND HANDLING

Use care in uncrating, unpacking, and handling this instrument. When opening the package, do not push tools into the container.

II-2 CHECKING

Inspect the unit for possible shipping damage. Rotate the controls and turn the switches for operating smoothness. Do not force the controls since permanent damage may result.

Any shipping damage or operational repairs should be referred to Texas Instruments Incorporated Repair Representative. Please see Section VII for addresses of the repair facilities.

NOTE: REMOVE THE SHORTING LINK FROM THE METER TERMINALS BEFORE APPLYING POWER.

II-3 OPERATING LOCATION

The instrument can be operated in any convenient location where appropriate power is available. 115 - 120V, ac, at 60 cps power is required.

II-4 CALIBRATION

4.1 With instrument energized, allow 10 minutes warm up.

4.2 Turn RANGE switch to "300" position.

II-4 CALIBRATION (Continued)

4.3 Short circuit probe contacts on metal surface.

4.4 Adjust d-c ZERO control to "zero" meter.

4.5 Turn RANGE switch to the ".01" position.

4.6 With probe still shorted, "zero" meter with the a-c ZERO control.

4.7 Turn RANGE switch to an appropriate range for a silicon crystal of known resistivity.

4.8 Place crystal on plexiglass insulating surface.

4.9 Press probe contacts down on crystal near the center.

NOTE: PROBE MUST BE PRESSED DOWN HARD ENOUGH TO COMPLETELY CONTRACT THE PROBE POINTS.

4.10 Using CAL ADJ control, adjust the meter to correspond exactly with the known resistivity value of the crystal.

4.11 The instrument is now calibrated and ready for use.

SECTION III - OPERATION

III-1 FRONT PANEL CONTROLS

1.1 INSTRUMENT PANEL CONTROLS

CONTROL	LOCATION	FUNCTION
INDICATING METER	Upper center of panel.	Resistivity indicator in Ω-cms of crystal being measured.
RANGE SWITCH	Center of panel.	Selects resistivity range.
BIAS JACK	Lower left-hand side of main panel.	External bias voltage input.
PROBE INPUT CONNECTOR	Bottom left-hand side of main panel.	Probe cable input connection.
MATERIAL P-N SWITCH	Bottom center of main panel.	Selects proper bias current direction for type of material being measured.
ON-OFF SWITCH	Bottom right-hand side of main panel.	Instrument power on and off.
NEON PILOT LAMP	Lower right-hand side of main panel.	Indicates power on when lighted.

III-1 FRONT PANEL CONTROLS (Continued)

1.2 SLICE ADAPTER PANEL CONTROLS

CONTROL	LOCATION	FUNCTION
ac ZERO	Top of slice adapter panel, left of center.	"Zeros" meter in .01 range position with probe contacts shorted.
dc ZERO	Top of slice adapter panel, left of center.	"Zeros" meter in 300 range position with probe contacts shorted.
CAL ADJ	Bottom of slice adapter panel, left-hand side.	Calibrates instrument with known resistivity value.
METER CAL	Bottom of slice adapter panel, left of center.	Adjusts meter sensitivity.
SLICE THICKNESS (3-Turn Potentiometer)	Center of slice adapter panel.	Directly dials slice thickness in mils.
BULK-SLICE SWITCH	Right-hand side of slice adapter panel.	Selects thickness category of crystal being measured.

III-2 OPERATIONAL PREPARATION

2.1 Connect instrument power cord to 115V, ac, 60cps power source.

2.2 Set ON-OFF switch to ON position.

2.3 Attach probe connector to the PROBE panel connector.

III-2.3 OPERATIONAL PREPARATION (Continued)

NOTE: IF A 4-POINT PROBE IS USED, CONNECT A TEST LEAD FROM THE CRYSTAL TEST FIXTURE TO THE BIAS JACK ON THE FRONT PANEL.

2.4 Calibrate instrument as in Para. II - 4.

III-3 OPERATING PROCEDURE

3.1 Measure crystal thickness to nearest 1/2 mil. with a micrometer.

3.2 Set BULK-SLICE switch in SLICE position when crystal is 0.037 inch thick or less.

3.3 Set SLICE THICKNESS potentiometer to correspond with measured thickness (in mils) of crystal slice.

3.4 Set P-N switch to type crystal being checked.

3.5 Place crystal to be checked on a crystal manipulating table. Crystal should be insulated from the test fixture when using the 5-point probe.

3.6 Fasten probe securely in holder on manipulator.

III-3.6 OPERATING PROCEDURE (Continued)

NOTE: HAND HOLDING THE PROBE IS NOT RECOMMENDED, SINCE CONSTANT CONTACT PRESSURE CANNOT BE MAINTAINED WHILE READING METER.

3.7 Set RANGE switch to 300 position, if approximate resistivity of crystal is unknown.

3.8 Lower probe until the spring-loaded tips contact the crystal and are fully depressed into the plastic probe head.

3.9 Set RANGE switch to position producing readings near midscale of meter.

NOTE: A SLIGHT METER FLUCTUATION MAY BE OBSERVED ON THE 0.01 AND 0.03 RANGE SCALES. A SMALL AMOUNT OF LOW FREQUENCY NOISE NOT CANCELLED BY THE DETECTOR CIRCUIT IS PICKED UP BY THE MORE SENSITIVE RANGES. READING ERRORS, CAUSED BY NOISE, ARE REDUCED BY OBSERVING THE AVERAGE METER READING.

BLOCK DIAGRAM

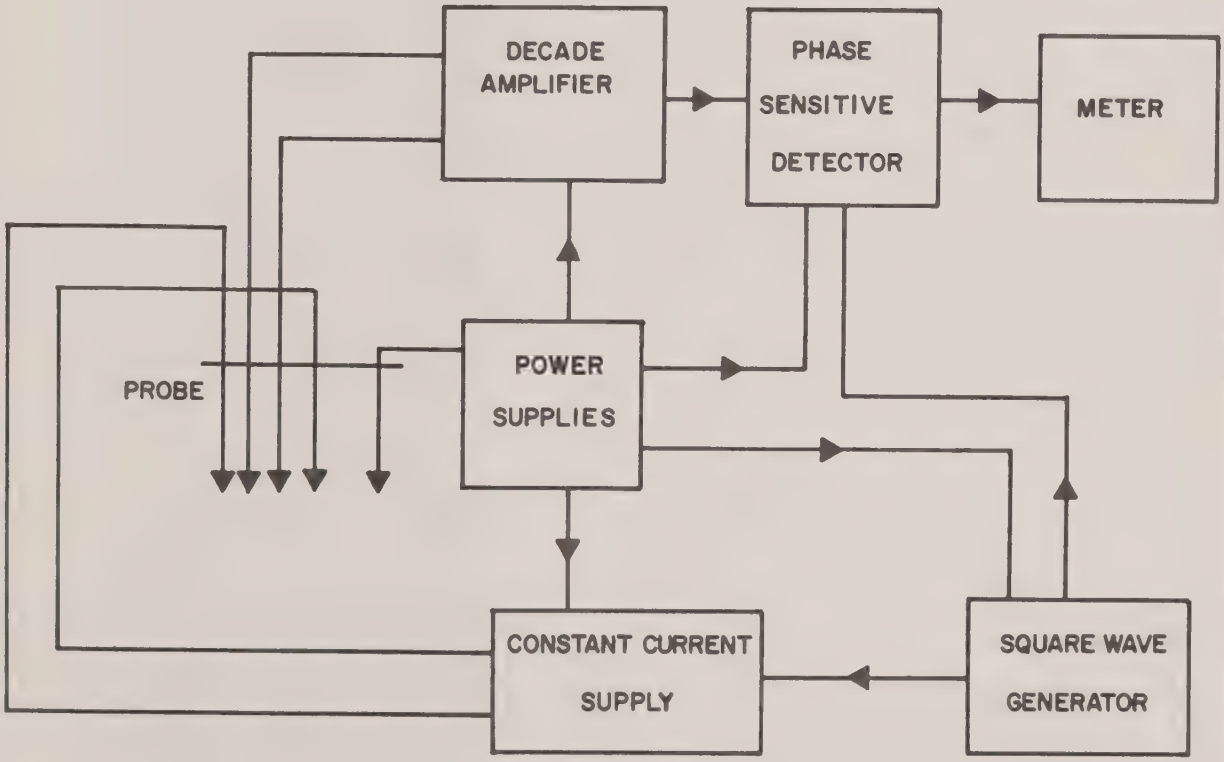


FIGURE 4-1

SECTION IV - OPERATIONAL THEORY

IV-1 GENERAL

If a small current biases all probes of a 4-point probe system in the forward direction, negligible contact resistance results. Resistivity can then be measured from a superimposed a-c signal.

Certain restrictions must be imposed to keep constant accuracy. The bias current should not be large enough to flood the area between probes with excess carriers. The peak a-c current should not be larger than the d-c bias. Otherwise, rectification can occur during some portions of the cycle.

A block diagram of the Crystal Resistivity Meter is shown in Figure 4-1. The two outer d-c biased probes are transformer coupled to a 1000 cps constant current supply. This supply in turn is fed from a square wave generator.

The a-c signal detected by the two center probes (also biased) is amplified by a decade amplifier. The output is then rectified by a phase sensitive detector and read on a sensitive d-c meter. Changing the current through the outer probes, and changing the gain of the decade amplifier changes resistivity ranges.

Each of these functional units is described in the following paragraphs.

IV-2 CIRCUIT DESCRIPTION (See Fig. 5-6 and 5-7)

2.1 SQUARE WAVE GENERATOR

The switching circuit composed of toroid T4 and transistors Q12 and Q13 generates the 1000 cps square wave. R44 and R45 supply feedback to sustain oscillation to the transistor bases.

IV-2.1 SQUARE WAVE GENERATOR (Continued)

T 4's tapped secondary winding provides driving voltage for the constant current supply. Q 12 and Q 13 emitters produce the reference signal for the phase sensitive detector.

2.2 CONSTANT CURRENT SUPPLY

Q 10 and Q 11 comprise the constant current supply providing probe current. Emitter resistors, R 47 through R 52, set the collector current of these transistors. CAL ADJ control, R 46, sets the base bias voltage. A 1 V (p-p) square wave switches the current between Q 10 and Q 11 by driving the bases, cutting off one transistor while the other conducts. Transformer T 3 is used for coupling the signal to the current probes.

2.3 DECADE AMPLIFIER

The signal across the voltage probe is coupled to the decade amplifier through T 1. A very high input impedence in the first stage results from using feedback on the Q 1 emitter. Q 2 and Q 3, connected in a beta-multiplier configuration, amplify the signal. A portion of this amplified signal is fed back to the Q 1 emitter through R 7.

The stage gain is determined by the ratio of R 7 to R 6. This provides a very stable voltage gain almost unaffected by changing transistor characteristics. Noise is reduced by non-inductive wire-wound resistors and the low noise characteristics of Q 1. Resistors R 2, R 37, and the a-c ZERO potentiometer, R 43, apply a small voltage from the square wave generator to the phase sensitive detector to balance any stray signal.

The second stage, consisting of Q 4, Q 5, and Q 6, is similar to the first stage. However, in this stage, the gain can be switched from 100:1 to 10:1. Selecting the appropriate feedback resistor, R 18 or R 19, or taking the signal directly from Q 4 emitter, provides switching.

The third stage, consisting of Q 7, Q 8, and Q 9, is also similar to the first stage. In this stage, the gain is set by the external slice circuit. Output is ccupled to the phase-sensitive detector through T 2.

IV-2.4 EXTERNAL SLICE CIRCUIT

A correction factor must be introduced to compensate for error resulting from measuring resistivity of slices thin enough to influence measurements. Over a fairly wide range of slice thickness, resistivity correction is linear for electrically isolated slices. The external slice circuit provides this correction by controlling the gain of the third stage. Varying the amount of feedback through a three turn potentiometer, R48 controls the gain.

With the BULK-SLICE switch in the SLICE position, the measured slice thickness may be set on the dial of R84. Direct resistivity reading is provided without additional calculation.

2.5 PHASE-SENSITIVE DETECTOR

A phase-sensitive detector circuit used in the meter circuit discriminates against noise. A 12V reference signal from the square wave generator is applied 180^{o} out of phase to the collectors of Q14 and Q15. Diodes CR1 and CR2 prevent application of positive voltages to the collectors. Separate windings on T2 bias the transistors to balance the emitter voltages with the d-c ZERO control. When Q14 and Q15 bases receive a signal in phase with the Q15 collector, the Q15 emitter voltage increases while the Q14 emitter voltage decreases. This causes the meter to deflect proportional to the signal magnitude.

2.6 POWER SUPPLIES

Power supply #1 provides 149V dc for the d-c probe bias. Three silicon power regulators, CR19, CR20, and CR21, regulate and provide 30V for operating the input shorting relay circuit. This power supply has a floating output so that the P-N switch may reverse its polarity.

IV-2.6 POWER SUPPLIES (Continued)

Power supply #2 provides 68V for the constant current generator and is regulated by a single 1N1833A silicon power regulator.

Power supply #3 provides well-regulated and filtered 12.4V for the decade amplifier. This circuit contains series regulator transistor, Q17, driver amplifier, Q18, and two 6.2V Zener diodes. The diodes provide a stable reference voltage.

Power supply #4 is identical to #3 except that the 12.4V output operates the phase-sensitive detector and the square wave generator.

2.7 INPUT SHORTING RELAY

When the probe is not in contact with the silicon surface, the input to the amplifier is floating. Thus, stray electrical pickup could be amplified and might overdrive the meter. To prevent this, a relay (K1) in the circuit shorts out the input to the amplifier when actual resistivity measurements are not being made. The d-c bias current operates this relay. An added amplifier section (Q16) insures reliable relay operation at low bias levels used on the high resistivity ranges.

SECTION V - MAINTENANCE

V-1 ALIGNMENT

1.1 Instruments required to service the Crystal Resistivity Meter are a volt-ohmeter (20,000 ohms/V or more), a 10,000Ω decade resistance box, and an oscilloscope. Special cases may require a transistor curve tracer and/or a beta-leakage checker. The only special equipment needed is an easily constructed Crystal Resistivity Meter Alignment-Jig. No special tools are required.

The Model 635 Crystal Rho Meter should be checked for alignment at least every three months.

1.2 Before attempting the following alignment procedure, construct the alignment jig shown in Fig. 5-5. The procedures listed must be performed in the exact sequence listed.

1) Set CAL ADJ pot to 3/4 cw rotation and slice thickness pot to 20 mils.

2) Set test jig alignment pot to zero and decade box to zero.

3) Set RANGE switch to 300 ohm-cm and zero meter with the d-c ZERO control.

4) Set RANGE switch to 0-01 ohm-cm and zero meter with the a-c ZERO control.

5) Set RANGE switch to 1.0 ohm-cm and alignment pot to 1000 (full clock-wise).

6) Set METER CAL to 1/4 cw rotation. Bring it to approximate full scale by increasing the decade box resistance (starting with smallest resistance).

7) Adjust meter to exactly full scale with the CAL ADJ.

8) Set the slice thickness pot to 10 mils. Adjust R83 (right-hand side of slice adapter frame) for a meter reading of 5 (1/2 scale).

V-1.2 ALIGNMENT (continued)

9) Set slice thickness pot to 20 mils. Adjust decade box and CAL ADJ for full-scale meter reading.

10) Repeat steps 8 and 9 until meter reads within one division of 5 in step 8.

11) Set the alignment pot to 500 and the slice thickness pot to 10 mils.

12) Adjust the decade box and the CAL ADJ control for a meter reading of 5.

13) Set the alignment pot to 1000. The meter should read 0.985 (almost full scale). If the meter reads below this value, increase the meter sensitivity with the METER CAL adjustment to move the meter slightly off scale.

14) Repeat steps 11 through 13 until meter reads 0.985. If meter reads over 0.985, decrease the meter sensitivity and check again. If troubles persist, check the zero adjustments as in steps 1, 2, 3, and 4.

15) Set the alignment pot to 1000 and the slice thickness pot to 20 mils.

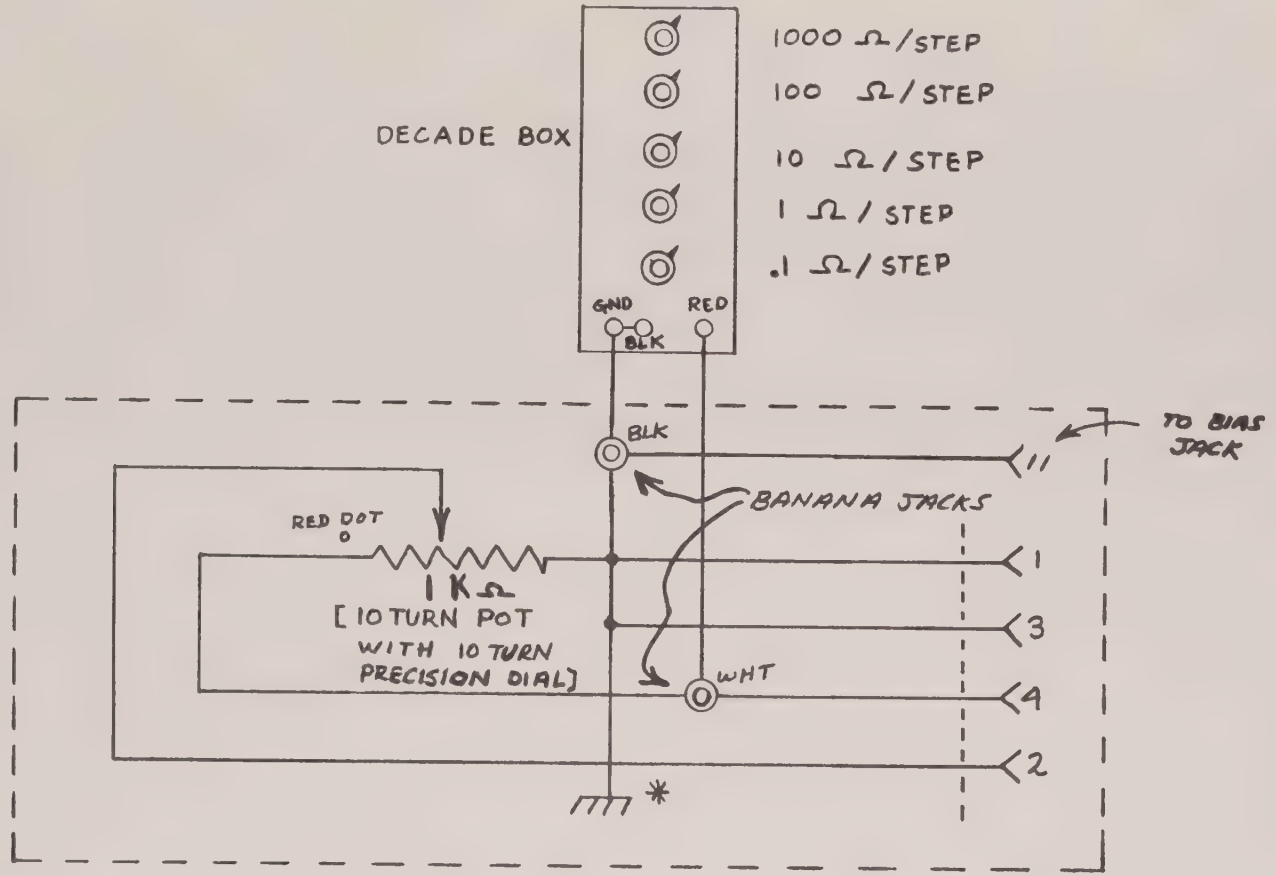
16) Adjust the meter to exactly full scale with the decade box and the CAL ADJ control.

17) Set alignment pot to 100, 200, 300, etc. and check the meter linearity. Meter should read within 1 division at all points.

18) Set the alignment pot to 320 and the BULK-SLICE switch to BULK.

NOTE: IF INSTRUMENT IS TO BE USED WITH PROBE HAVING CONTACT SPACING OTHER THAN 45 MILS, THE ALIGNMENT POT SETTING MUST BE DETERMINED BY THE FOLLOWING FORMULA:

$$\text{POT SETTING} = \frac{14400}{\text{PROBE SPACING (IN MILS)}}$$



ALIGNMENT JIG –

CRYSTAL Ø METER
FIGURE 5-5

* TEST JIG CHASSIS GROUND

A 190182

V-1.2 ALIGNMENT (continued)

19) Adjust R82 (slice adapter unit) to make the meter read exactly full scale.

20) Set the RANGE switch to the 300 ohm-cm position, and set the alignment pot to 900.

21) Adjust the meter to exactly full scale with the decade box and the CAL ADJ control.

22) Set the alignment pot to 300, and turn RANGE switch to the 100 ohm-cm position.

23) Re-adjust the alignment pot to obtain an exact full-scale reading on the meter. The alignment pot should read 300 ± 6.

24) Set the decade box to 100-ohms, and the alignment pot to 1000.

25) Adjust CAL ADJ control to bring meter to full scale. Set alignment pot to 300 and turn RANGE switch to 30 ohm-cm position.

26) Adjust alignment pot to bring meter reading to exactly full scale. The alignment pot should read 300 ± 6.

27) Set alignment pot to 100, and turn RANGE switch to the 10 ohm-cm position.

28) Adjust alignment pot to bring meter to full scale. It should read 100 ± 4.

29) Set decade box to 9-ohms and set alignment pot to zero.

30) Turn RANGE switch to the 300 ohm-cm range and zero meter with d-c ZERO control. Return the RANGE switch to the 10 ohm-cm position.

31) Set the alignment pot to 1000, and adjust the CAL ADJ control to bring the meter to full scale.

32) Set the alignment pot to 300, and set the RANGE switch to the 3 ohm-cm position.

V-1.2 ALIGNMENT (continued)

33) Adjust the alignment pot to bring the meter to exactly full scale. It should read 300 ± 6.

34) Set the alignment pot to 100, and turn RANGE switch to the 1.0 ohm-cm position.

35) Adjust the alignment pot to bring the meter to exactly full scale. It should read 100 ± 2.

36) Set alignment pot to zero, and set decade box to zero ohms.

37) Turn RANGE switch to 0.01 ohm-cm position. Zero the meter with a-c ZERO control.

38) Set RANGE switch to the 1.0 ohm-cm position.

39) Set decade box to 0.9 ohms, and alignment pot to 1000.

40) Adjust CAL ADJ to bring meter to full scale.

41) Set alignment pot to exactly 100 ohms, and set RANGE switch to 0.1 ohm-cm position.

42) Adjust R19 (on PCB 1) until meter reads exactly full scale.

43) Set RANGE switch to 0.3 ohm-cm position and alignment pot to 300.

44) Adjust alignment pot to bring meter to exactly full scale. Pot should read 300 ± 6.

45) Set decade box to 0.1 ohms, and alignment pot to 1000.

46) Set RANGE switch to the 0.1 ohm-cm position. Re-adjust the a-c ZERO control as per steps 2 and 4 if necessary.

47) Set the alignment pot to zero and set the RANGE switch to the 0.01 ohm-cm position.

48) Adjust the CAL ADJ control to bring the meter to exactly full scale.

V-1.2 ALIGNMENT (continued)

49) Set alignment pot to 100. Adjust R18 (on PCB-1) to bring the meter to exactly full scale.

50) Disconnect the alignment circuit and connect the probe to the unit. Alignment is now complete. Proceed with calibration. (See Para. II-5).

V-2 VOLTAGE MEASUREMENTS

2.1 AMPLIFIER VOLTAGE CHART

POINT OF MEASUREMENT*	VOLTAGE**	ADJUSTMENT TO REACH PROPER VOLTAGE
Collector Q1	+4.4 to 5.5 V	Substitute R4
Collector Q2	+5.4 to 6.5 V	Substitute R8
Collector Q4	+4.1 to 4.5 V	Adjust R7
Collector Q5	+6 to 7 V	Substitute R16
Collector Q7	+7 to 8 V	Substitute R24 or Q7 if necessary
Collector Q9	+11.4 to 12.6 V	

2.2 OSCILLATOR VOLTAGE CHART

POINT OF MEASUREMENT*	VOLTAGE**
Collector Q12	-11.4 V to -12.4 V
Base Q12	+1.5 V ± 10%
Base Q13	+1.5 V ± 10%
Collector Q15	-7.5 V ± 10%
Collector Q10	+68 V ± 10%
Collector Q11	+68 V ± 10%

V-2 VOLTAGE MEASUREMENTS (continued)

*See schematic diagram (Fig. 5-6) for base and emitter voltages.

**Voltages are measured with a 20,000 ohms/V meter with respect to chassis ground.

V-3 PROBE POINT REPLACEMENT

3.1 Replace the permametal points in the Texas Instruments probe when they become worn or damaged.

3.2 Replace points as follows:

3.2.1 Hold the probe vertically (with contacts pointing downward) and unscrew the knurled retaining ring holding plastic head to handle.

3.2.2 While holding the plastic head in a vertical position, remove and replace points with a pair of tweezers.

3.2.3 Carefully insert spring wires into probe tip sockets and join plastic head and handle.

3.2.4 Connect handle and plastic head with knurled ring.

SECTION V - MAINTENANCE

V-4 TROUBLE SHOOTING

SYMPTOM	POSSIBLE CAUSE	REMEDY
4.1 Instrument not operating.	1) Line cord not plugged in.	Plug in line cord.
	2) Fuse blown.	Replace fuse.
	3) Defective line cord.	Replace line cord.
	4) One or more power supplies not operating.	a) Refer to schematic diagram (Fig. 5-7). b) Check all power voltages. (All voltages should be within 10%). c) Locate inoperative unit. Replace defective components.
4.2 Instrument is operating but pilot lamp does not light.	Defective pilot lamp.	Replace pilot lamp.
4.3 Meter lamp does not light.	1) Lamp(s) defective or burned out.	Replace lamp(s).
	2) Transformer T5 defective.	Check voltage output of T5 low-voltage winding. Replace transformer if necessary.
	3) Defective wiring	Check associated wiring. Repair or place as required.

V-4 TROUBLE SHOOTING

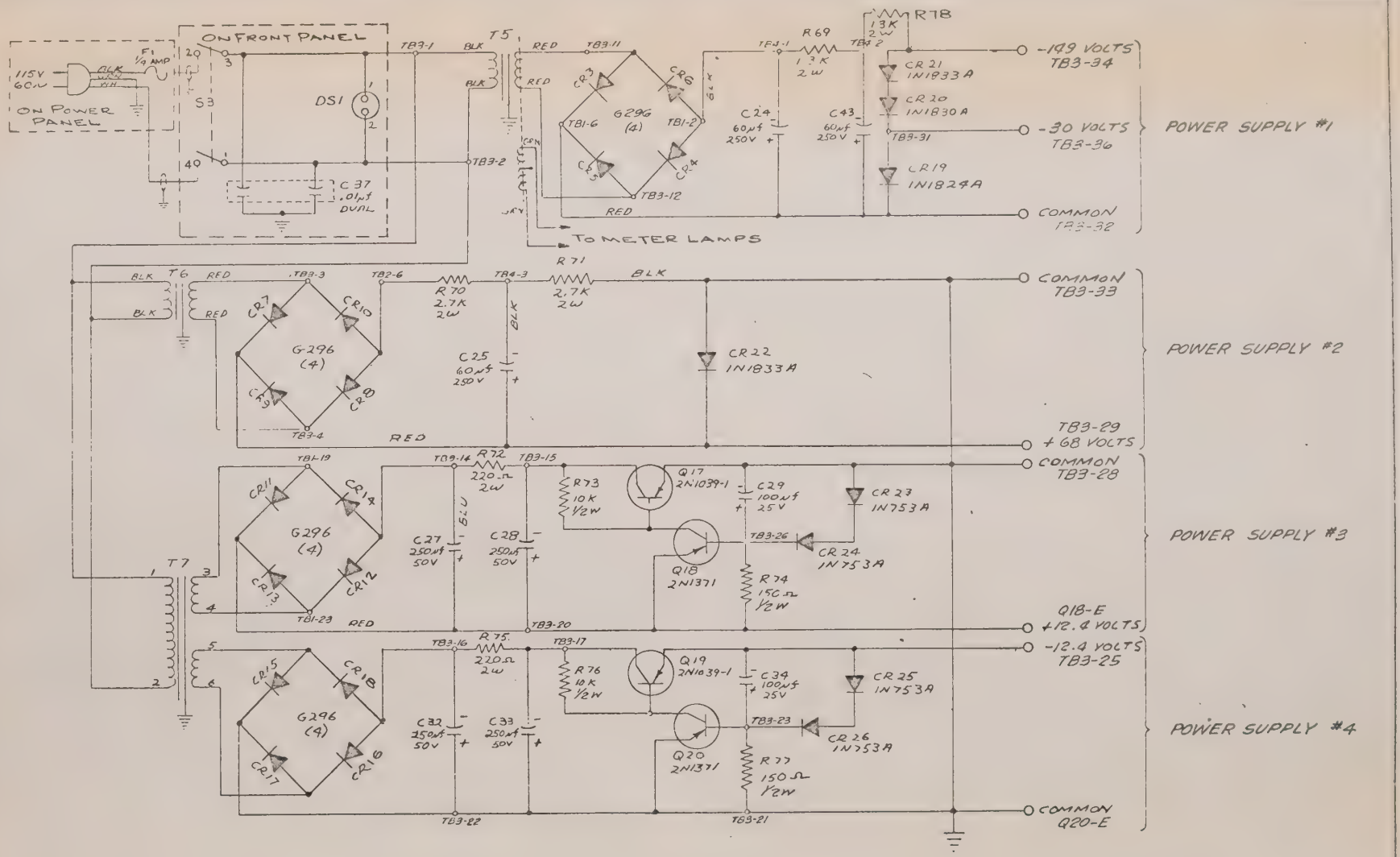
SYMPTOM	POSSIBLE CAUSE	REMEDY
4.4 Instrument is not working, faint 1,000 cps whistle cannot be heard coming from T4.	Oscillator not working.	Check d-c voltages associated with Q12 and Q13. Trace circuit, isolate trouble, and correct as required.
4.5 Meter tends to deflect the wrong way.	1) Defective components in associated circuitry of Q14 and Q15. 2) Q14 and Q15 mismatched.	Check for proper voltages and defective components. Refer to schematic diagram and Fig. 5-6. Check for "beta" matching. If not within 5%, change transistors.
4.6 Meter deflects but does not zero with d-c ADJ when RANGE switch is in 300 ohm-cm position.		a) Refer to schematic diagram (Fig. 5-6). b) Check waveform at Q12 and Q13 emitter. Square wave generator output should read 24V from emitters to ground.
4.7 Meter readings non-linear.	Constant current supply defective.	a) Check Q10, Q11, and associated circuitry. Base waveforms should be sharp, square-waves. b) Normal ringing at collectors is filtered out by amplifier. Check this by placing probe contacts on a crystal and observing waveform at amplifier output (Q9 collector). NOTE: Q10 and Q11 MUST be closely matched high "beta" units with low V_{be}.

V-4 TROUBLE SHOOTING

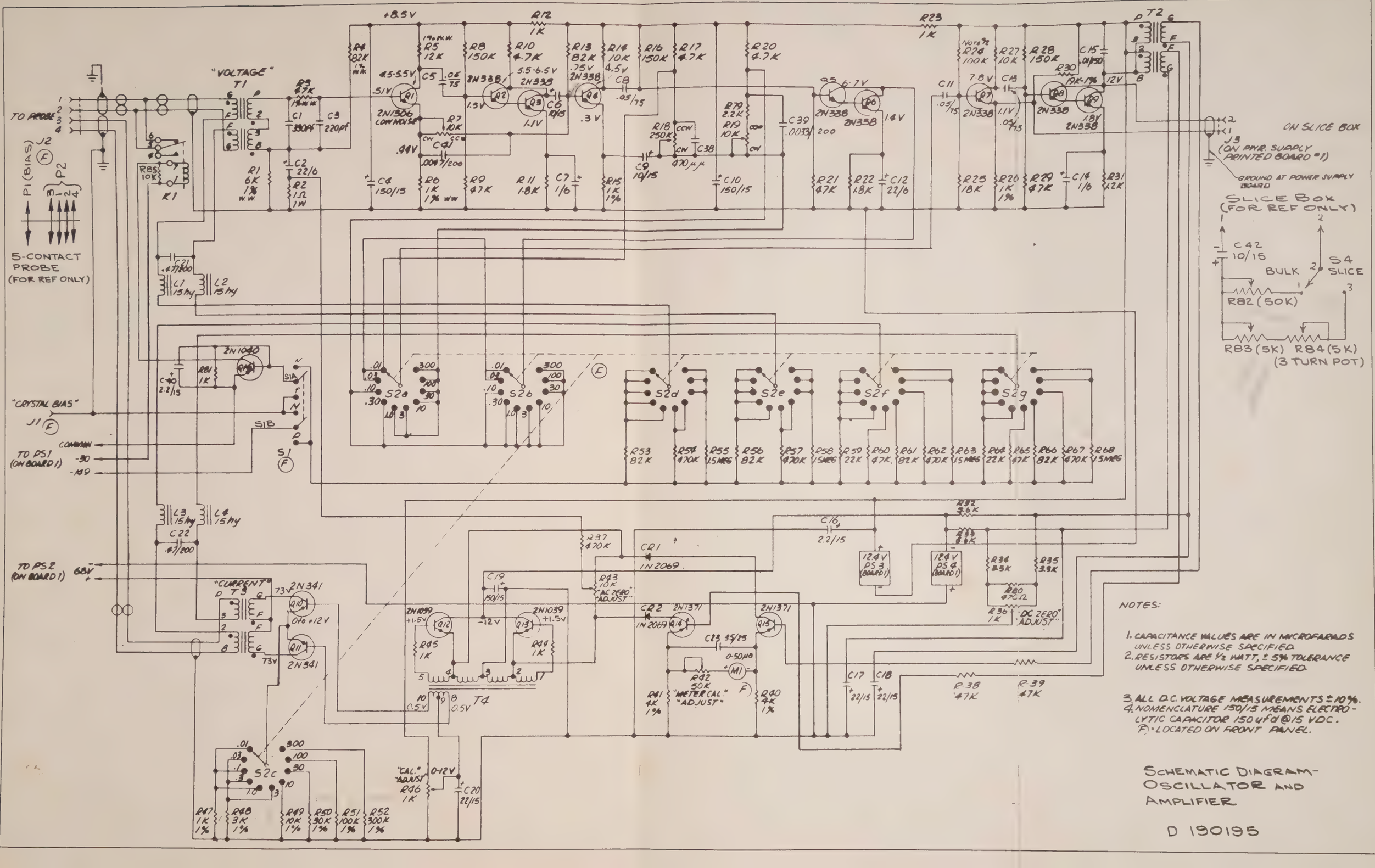
SYMPTOM	POSSIBLE CAUSE	REMEDY
4.8 Phase sensitive detector (Q14 and Q15) appears to to malfunction but d-c voltages are correct.	Large stray signal in decade amplifier output.	Check and correct malfunctioning decade amplifier.*
4.9 a-c ADJ not operating.	1) Short or open circuit in decade amplifier input. 2) Defective R2 and/or C2.	Check and trace down defective circuits* and components in decade amplifiers input sections. Replace components required. Check and replace as required.
4.10 Instrument not aligning properly on one or more ranges.	Constant current circuit malfunction.	See correction for non-linear meter readings. (Item V-3.7).

* Trouble in the decade amplifier can be isolated by standard signal tracing methods and by checking d-c operating voltages.

NOTE PROBE TIPS MUST BE IN CONTACT WITH CRYSTAL TO OPEN RELAY K1 AND SEND THE SIGNAL TO THE AMPLIFIER.



SCHEMATIC —
CRYSTAL RHO METER
POWER SUPPLY

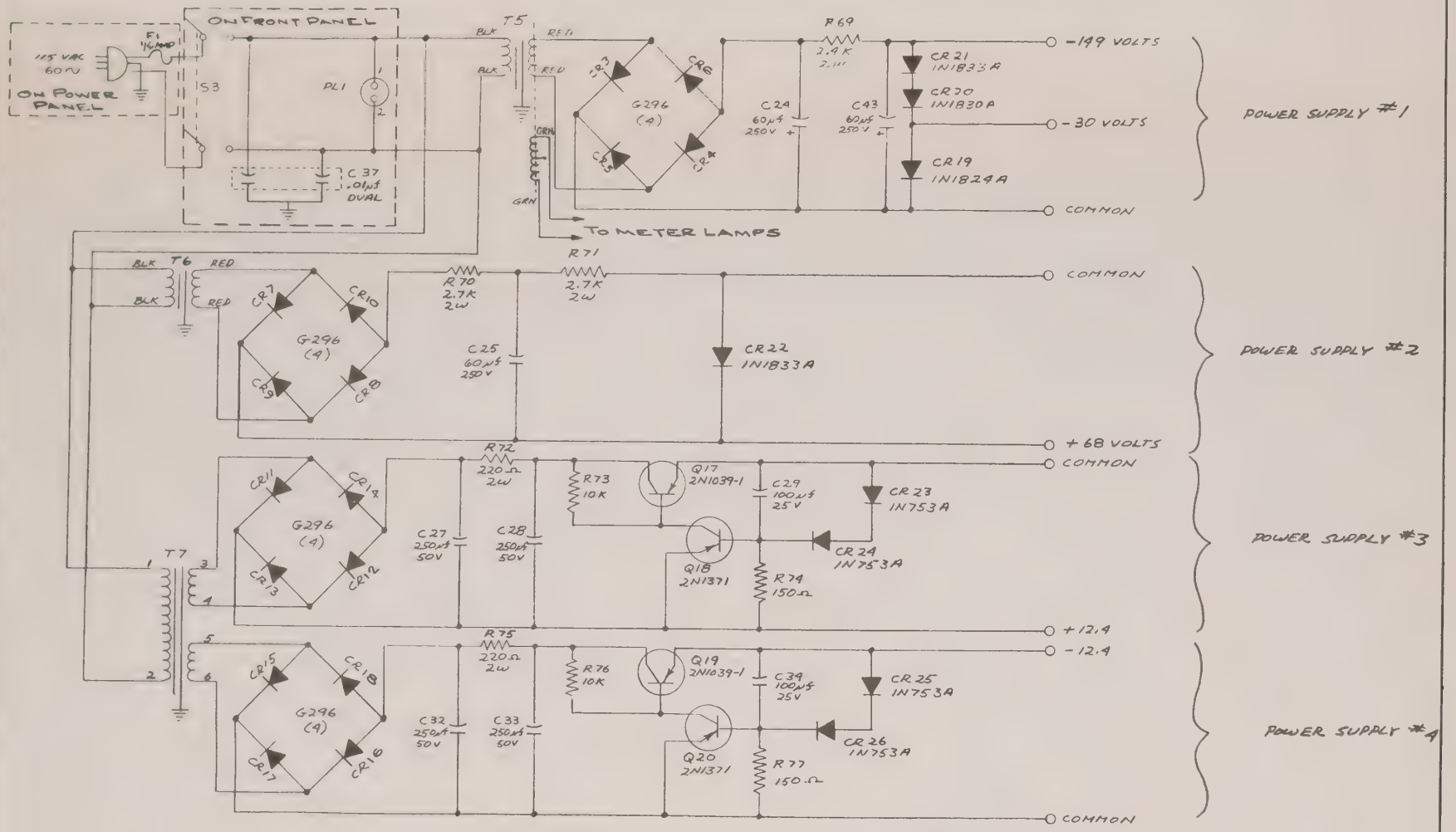


NOTES:

1. CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. RESISTORS ARE ½ WATT, ± 5% TOLERANCE UNLESS OTHERWISE SPECIFIED.
3. ALL D.C. VOLTAGE MEASUREMENTS ± 10%.
4. NOMENCLATURE 150/15 MEANS ELECTROLYTIC CAPACITOR 150 μfd @ 15 VDC.
(F) = LOCATED ON FRONT PANEL.

SCHEMATIC DIAGRAM-
OSCILLATOR AND
AMPLIFIER

D 190195



SCHEMATIC –
POWER SUPPLY –
CRYSTAL ρ METER
FIGURE 5-7

190126

REV. NONE

SECTION VI - REPLACEABLE PARTS

VI-1 GENERAL

For trouble-shooting or instrument repair and component replacement, locate schematic diagram components by reference number on the parts lists in this section.

Texas Instruments Incorporated supplies listed parts on order. When ordering parts, give full description, including instrument model number, serial number, type, and quantity of part desired. Address the order to:

Product Services Manager
Texas Instruments Incorporated
3609 Buffalo Speedway
Houston 6, Texas

VI-2 REPLACEABLE PARTS LISTS

REF. NO.	TI PART NO.	DESCRIPTION	QTY.
		CAPACITORS	
C 1		330 pf, CM 15E331	1
C 3		220 pf, CM 15E221	1
C4, C10 C 19		150 µf, 15 V, NLW 150-15	3
C 5, C 8 C 11, C 13		0.05 µf, Centralab, DDA 503	4
C 9		10 µf, 15 V NLW 10-15	1
C 15		0.01 µf, Centralab, DD 3-103	1
C 16		2.2 µf, 15 V, SCM 225 FPO, 15A4	1
C 17, C 18		22 µf, 15 V, SCM 226 BPO, 15A4	2
C 20, C 12		25 µf, 10 V, NLW-25-10	2
C 21, C 22		0.47 µf, 200 V, PM 2P47	2
C 23		39 µf, 35 V, SCM 396HPO, 35A4	1
C 24, C 25 C 43		60 µf, 250 V, BR 6025	3
C 27, C 28 C 32, C 33		250 µf, 50 V, BR 2505	4
C 29, C 34		100 µf, 25 V, BBR 100-25	2
C 38		470 pf, CM 15E471	1
C 39		0.0033 µf, 200 V, CAPCO MMW	1

VI-2 PARTS LISTS (Continued)

REF. NO.	TI PART NO.	DESCRIPTION	QTY.
C 40		3 μf, 25 V, NLW 3-25	1
C 41		0.0047 μf, 200 V, CAPCO MMW	1
C 42		10 μf, 15 V, SCM 106 BPO, 15A4	1
		DIODES	
		1N540	2
CR 3 thru CR 18		G 296	16
CR 19		1N1824A	1
CR 20		1N1830A	1
CR21, CR22		1N1833A	2
CR 23 thru CR 26		1N753A	4
		CONNECTORS	
		AMPHENOL PC 22	1
		AMPHENOL 91 PC 4F	1
J 1		JACK, Banana, H. H. Smith #205 (Red)	1
K 1		RELAY, PB SM-5LS	1
L 1, L 4		CHOKES, UTC MQA 18	2
M 1		METER, API 561	1

VI-2 PARTS LISTS (Continued)

REF. NO.	TI PART NO.	DESCRIPTION	QTY.
PL1, PL2		LAMPS, GE #47	2
		TRANSISTORS	
Q1		2N1306	1
Q2 thru Q9		2N338	8
Q10, Q11		2N341 (Matched Pair)	1 Pr.
Q12, Q13		2N1039	2
Q14, Q15		2N1371 (Matched Pair)	1 Pr.
Q16		2N1040	1
Q17, Q19		2N1039-1	2
Q18, Q20		2N1371	2
		RESISTORS	
R1		6 K, 1%, 1/4 W, WWA 13	1
R2		1 Ω, 5%, 1 W	1
R3		47K, 1%, 1/4 W, WWA 13	1
R4		82 K, 1%, 1/2 W, WWA 22	1
R5		12 K, " " "	1
R6		1 K, " 1/4 W, WWA 13	1
R15, R26		1 K, " 1/2 W, WWA 22	2
R30		19 K, " " "	1

VI-2 PARTS LISTS (Continued)

REF. NO.	TI PART NO.	DESCRIPTION	QTY.
R 40, R 41		4K, 1%, 1/2 W, WWA 22	2
R 48		3K, " " "	1
R 49		10K, " " "	1
R 50		30K, " " "	1
R 51		100K, " " "	1
R 52		300K, " " "	1
R 69		2.4K, 5%, 2 W, Carbon	1
R 70, R 71		2.7K, " " "	2
R 72, R 75		220 Ω, " " "	2
R 74, R 77		150 Ω, " 1/2 W, "	2
		POTENTIOMETERS	
R 7, R 43		10K, OHMITE AS 3607	2
R 18		250K, " AS 3611	1
R 36, R 46		1K, BOURNS 224S-1-102M TRIMPOT	2
R 42, R 82		50K, " 224S-1-503M "	2
R 43		10K, " 224S-1-103M "	1
R 83		5K, " 224S-1-502M "	1
R 84		5K, 3-Turn, SPECTROL #830	1

VI-2 PARTS LISTS (Continued)

REF. NO.	TI PART NO.	DESCRIPTION	QTY.
S1, S3		DPDT, C-H8373K8	2
S2		INDEX, CENTRALAB PA 302	1
S2		WAFER, " PA 1	ギ 7
S4		DPST, C-H8370K8	1
		TRANSFORMERS	
T1, T2, T3		UTC A-18	3
		26 R60	2
	440079-1	TI	1
	424337-1	TI	1
TB1, TB2	81668	TERMINAL BOARDS (097)	2
		SOCKETS	
		EBY PC7C	1
		GRAYHILL 22-11	4
		" 22-16	16
		MISCELLANEOUS	
		DIAL, Beckman Duodial Model RB	1
	44923-1	BUSHING, Power Cord, TI	1
	84031-2	FOOT, Rubber, TI	4

VI-2 PARTS LISTS (Concluded)

REF. NO.	TI PART NO.	DESCRIPTION	QTY.
	85913-4	CLAMP, Cable (097)	3
	88035-2	CORD, Line (097)	1
	88069-4	TERMINAL STRIP	1
	88104-2	KNOB (097)	1

SECTION VII - PACKING AND SHIPPING

VII-1 GENERAL

When the instrument is shipped commercially, it should be protected against shipping damage by proper packing. Original packing is preferred, but new packaging material may be used if the original material is not available.

VII-2 PACKING INSTRUCTIONS

2.1 Short the meter terminals.

2.2 Make sure all module retaining screws are securely tightened.

2.3 Coil power cord around bracket on back of instrument.

2.4 Wrap instrument in heavy Kraft paper to protect finish and place in a snugly fitting fibre-board box.

2.5 Obtain a second box approximately 6" larger in all directions than the instrument container. Place a 3" thick pad of cushioning material (preferably rubberized horsehair) in the bottom of this box.

2.6 Place the boxed instrument in the center of the second box on the bottom padding. Trim 3" thick cushioning pads to the outside box size and fit them around the four sides and on top of the boxed instrument.

2.7 Carefully and completely seal the second box and address so that the destination is clearly visible in two places on the outside.

2.8 Address the labels and ship prepaid to:

Texas Instruments Incorporated
3609 Buffalo Speedway
Houston 6, Texas

Attention: Product Services Mgr.

www.manualsplus.com
1033934